THE PROGRESS OF SCIENCE

THE PRINCIPLE OF RELATIVITY AND THE DEFLECTION OF LIGHT BY GRAVITATION

CABLE despatches from England report a joint meeting on November 6 of the Royal Society and the Royal Astronomical Society, at which Sir F. W. Dyson, the astronomer royal, and Dr. A. C. Crommelin, of the Royal Observatory at Greenwich, announced that an examination of the photographic plates taken during the solar eclipse of last May show a deflection of the rays of light from the stars in their passage past the sun that accords with the theoretical degree predicted by Dr. Albert Einstein's theory of relativity, namely, 1.7 second of arc.

In the solar eclipse of 1918 the Lick Observatory photographed the stars in the region immediately surrounding the sun in order to test the Einstein theory, but the results seem not to have been published. There is presumably no question about the correct measurement of the English plates. The same results seem to have been obtained from the photographs which had been taken at Sobral in north Brazil and at the Island of Principi off the African west coast. Neither does there appear to be any alternate explanation of the phenomenon. Professor H. F. Newall, of Cambridge, is said to have suggested at the meeting that it might be due to an unknown solar atmosphere, further in extent than had been supposed and with unknown properties, but it is not clear how a hypothesis in itself unlikely would account for the deflections, if they are those called for by the Einstein theory.

It is further the case that the theory had already been confirmed by another astronomical fact, the motion of the planet Mercury, which accords with the theory of relativity, but can not be accounted for on the exact assumptions of Newton's law of gravitation. On the other hand, a shift of the lines in the spectrum toward red in a strong gravitational field, which the Einstein theory requires, has been looked for unsuccessfully.

The experiment of the English astronomers is in itself very simple. If the rays from the stars are deflected by the gravitational field of the sun, this can not ordinarily be observed, for it is impossible to photograph them in the sun's light. But at the time of a total eclipse the bright stars, far beyond the sun but near it in the firmament, can be photographed, and their apparent positions can be compared with the positions of the same stars when the rays do not pass near the sun. The change in the apparent positions of the stars, presumably through deflection of their light by gravitation, can thus be readily measured.

Sir J. J. Thomson, the president of the Royal Society, is reported to have said at the meeting that it was the greatest discovery in connection with gravitation since Newton enunciated that principle. This in itself might not mean much, for no discovery in regard to gravitation has been made since the time of Newton. But if the results lead to the acceptance of the whole theory of relativity, as developed by Einstein, then indeed not only our theories of gravitation and the ether, but our whole conception of space, time, mass and

motion must be altered more fundamentally than has ever before occurred in the history of science.

A clear account of the theory of relativity by Professor William Marshall, of Purdue University, will be found in the MONTHLY for May, 1914. Albert Einstein, then employed in the Swiss patent office, formulated the theory in 1905 with remarkable perfection in a short article entitled "Concerning the electrodynamics of moving bodies." In 1911 he published the paper which deduces the influence of gravity on the propagation of light which is said now to be confirmed by the astronomical observations. Dr. Einstein was appointed to a chair in the Zurich Polytechnic School and was later called to one of the research institutions established in affiliation with the University of Berlin.

The Einstein theory may be said to have had its origin in an effort to explain the experiment on the so-called ether-drift, made by Professors Michelson and Morley somewhat more than thirty years ago at the Western Reserve University. Michelson suggested that the negative result of the experiment could be accounted for by supposing that the apparatus underwent a shortening in the direction of the line of motion. Later Professor Lorenz, the Dutch physicist, assumed that everything gets shortened as it moves through space; that the 8,000 miles of the earth's diameter is shortened up by three or four inches, an amount sufficient to provide a scientific explanation for the failure of the Michelson and Morley attempt to detect that the earth was moving through the ether. Then Einstein proposed his generalization that it is impossible to detect the effects of motion, except when it is relative to another material body, or that it is impossible to detect the absolute velocity of any body through space.

Many queer things have been written and will be written in the daily press concerning the theory of relativity, but perhaps none more strange than the logical deductions from the theory. As an example, Einstein's words (as translated by Professor Wetzel in *Science*, October 3, 1913), in the paper of 1911, may be quoted:

> Give the watch a very large velocity (approximating the velocity of light) so that it travels with uniform speed; after it has gone a long distance give it an impulse in the opposite direction so that it returns to its starting point. We then observe that the hand of this watch during its entire journey to and fro has remained practically at a standstill, while the hand of an exactly similar watch which did not move with respect to the coordinate system (the sun or earth) has changed its position considerably.
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> We must add: what is true for our watch with respect to time must also be true of any other enclosed physical system, whatever its nature, because in all our thinking the watch was introduced simply as a representative of all physical actions or occurrences. Thus, for example, we could substitute for the watch a living organism enclosed in a box. Were it hurled through space like the watch, it would be possible for the organism, after a flight of whatever distance, to return to its starting point practically unchanged, while an exactly similar organism which remained motionless at the starting point might have given place to new generations. For the organism in motion time was but a moment, if its speed approached the velocity of light. This is a necessary consequence of our fundamental assumptions and one which experience imposes on us.

THE DISINTEGRATION OF ATOMS AND ATOMIC ENERGY

THE theory of relativity, though based on physical observations and